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Title: **METHOD FOR FAST MANUFACTURING AND ASSEMBLING OF HOT RUNNER SYSTEMS**

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FIELD OF INVENTION

The present invention relates to a method for fast manufacturing and assembling of hot runner systems. More specifically, it relates to a method of manufacturing and assembling customized hot runner systems using a wide selection of standard manifold plates, nozzles, and other stock components.

BACKGROUND OF THE INVENTION

Hot runner systems for injection molding are well-known in the art. Hot runner systems generally comprise a manifold plate with a plurality of injection nozzles. The manifold plates used in such hot runner systems come in a variety of different shapes, configurations, and styles, depending on customer and/or manufacturing preferences. For example, the manifold plate may have a straight bar shape, X-shape, H-shape, Y-shape, Y-plate shape, or H-plate shape. In addition, the manifold plate may be configured with a wide range of lengths (e.g., 150 millimeters to 600 millimeters) and thickness (e.g., 25 millimeters to 40 millimeters), and the flow channels of the manifold plate may be configured with a wide range of diameters (e.g., 3 millimeters to 12 millimeters).

The number, pitch spacing, and type of nozzles used with the manifold plate may also vary depending on customer and/or manufacturing preferences. For instance, anywhere from 2 to 8 nozzles (or more) may be used with a manifold plate, and each nozzle may be spaced (i.e., nozzle pitch) anywhere from 30 mm to 250 mm away from the melt inlet of the manifold plate.

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Moreover, the nozzles may have a number of different shapes, sizes, tips styles, gate configurations (e.g., thermal or valve gating), and shot weight ranges.

Obviously, it would be very impractical and expensive, if not impossible, to pre-manufacture and pre-assemble all of the possible existing combinations of hot runner systems, and have them stored in inventory for delivering to a customer upon placing an order. In contrast, it would be undesirable to unduly limit the shapes, configurations, styles, types, and/or sizes of the manifold plates and nozzles used in hot runners systems, and restrict customers' ability to customize their hot runner systems. Thus, in order to accommodate their various designs and customers' custom specifications, hot runner systems are typically not manufactured or assembled until after customers have placed orders for the hot runner systems and specified their design requirements. Consequently, the manufacturing and assembling of such hot runner systems can take several weeks, if not several months, to complete, since all of the work is done after the customer places an order.

Claimed steps

A typical hot runner system is manufactured and assembled with the following prior art method. In the first step, a customer's order is taken by the hot runner maker, including the customer's specifications for the ordered hot runner system. Based on the customer's specifications, the raw material for the manifold is selected in the second step, and the manifold plate is manufactured in the third step by cutting and grinding the raw material into the desired manifold plate dimensions. Next, in the fourth step, a heating element is added to the manifold plate, and in the fifth step, the main and auxiliary flow channels are drilled in the manifold plate. Then, in the sixth step, holes for attachments to the manifold plate are drilled, bored, and/or

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machined, and the specified injection nozzles are manufactured in the seventh step. Finally, in the eighth step, the specified components, including the injection nozzles, are attached to the manifold plate, and the customized hot runner system is completed and delivered to the customer in the ninth step. As previously mentioned, this prior art method can take several weeks, if not months, to complete.

Accordingly, it would be desirable to provide a method for speeding up the manufacturing and assembling processes involved with hot runner systems to allow customers to receive their hot runner systems in a shorter period of time (i.e., in a matter of days, rather than weeks), yet still provide customers with the flexibility to customize their hot runner systems. The present invention accomplishes this desire and overcomes the problems with the prior art by providing a method for quickly manufacturing and assembling customized hot runner systems using a wide selection of standard manifold plates, nozzles, and other stock components, such as manifold heating elements and plugs. The method of the present invention enables hot runner systems to be rapidly assembled from partially manufactured components, while still allowing customers to choose from a broad range of options for manifold plates and injection nozzles, and to specify the requirements for their hot runner systems.

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SUMMARY OF THE INVENTION

The present invention provides a method for manufacturing and assembling hot runner systems comprising the steps of manufacturing a plurality of manifold plates, injection nozzles, and plugs, and adding heating elements to the manifold plates. The method of the present invention also comprises the steps of drilling flow channels into the manifold plates, and placing the manifold plates, the injection nozzles, and the plugs in stock. The method of the present invention further comprises the steps of taking orders with specifications for hot runner systems, and removing from stock the manifold plates, the injection nozzles, and the plugs that correspond to the specifications of the orders. In addition, the method of the present invention comprises the steps of boring out holes for the plugs in the manifold plates at locations that correspond to the specifications of the orders, inserting the plugs into the bored out holes of the manifold plates, and attaching the nozzles to the manifold plates in alignment with the plugs.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustrating a preferred method of the present invention for manufacturing and assembling a hot runner system.

FIG. 2 is a flow diagram illustrating a preferred method of the present invention for manufacturing and assembling a hot runner system.

FIG. 3A-3J are perspective views of a partial straight bar, two nozzle hot runner system that is manufactured and assembled according to the method of FIG. 2.

FIG. 3K-3M are detailed top and side views of the partial straight bar, two nozzle hot runner system of FIG. 3J, as well as partial exemplary X-shaped and H-shaped, four nozzle hot runner systems, together with tables for preferable nozzle pitches and manifold dimensions for such hot runner systems.

FIG. 4 is a partial cross-sectional view of a plug of the hot runner system of FIG. 3J, taken along line 4-4.

FIG. 5 is a side cross-sectional view of the plug of FIG. 4 rotated into a lateral position and parallel orientation.

FIG. 6 is a partial side cross-sectional view of the plug of FIG. 5 positioned within a modified bore that has been rotated into a lateral position and parallel orientation corresponding to the plug.

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DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 illustrates a block diagram for a preferred method 10 of the present invention for high-speed assembling and manufacturing of customized hot runner systems. As shown in FIG. 1, the method 10 preferably starts out with approximately 80% of the manufacturing and assembling of the hot runner systems and the standard manifolds A, B, C being completed in a first phase, referred to herein as Phase 1 (see below). A customer may then place an order for the stocked, 80% complete hot runner systems and choose between manifold A, B, and/or C. After an order has been taken, the necessary manifold(s) and components are removed from stock, and 100% of the manufacturing and assembling of the hot runner systems is completed in a second phase, referred to herein as Phase 2 (see below). The hot runner systems are completed based on the factors specified in the customer's order, such as the nozzle pitches, X.

FIG. 2 shows a flow diagram illustrating the preferred method 10 of the present invention in more detail. As shown in FIG. 2, the method 10 begins with Step 12 wherein raw material is selected for a plurality of different manifold plates. In Step 14, a variety of different standard manifold plates are manufactured by cutting and grinding the selected raw material into various standard manifold plate shapes, configurations, and dimensions. In one exemplary embodiment of the method of the present invention, the selected raw material is steel that is manufactured into one of a straight bar shape, X-shape, H-shape, Y-shape, Y-plate shape, or H-plate shape. In this exemplary method, each manifold plate may also be configured with a wide range of thickness, preferably from about 30 millimeters to about 37 millimeters, and the flow channels of the manifold plates may be configured with a wide range of diameters, preferably from about 3

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millimeters to about 12 millimeters. For more information on the various shapes, configurations, sizes, and styles of the manifold plates suitable for use with the present invention, see U.S. Patent No. 4,761,343, U.S. Patent No. 5,007,821, U.S. Patent No. 5,030,084, U.S. Patent No. 5, 441, 197, U.S. Patent No. 5,705, 202, and U.S. Patent No. 5,792,493, all of which are specifically incorporated in their entirety herein by reference.

As shown in FIG. 2, the next Step in the method 10 of the present invention is Step 16, wherein heating element grooves are milled into the manifold plates. In Step 18, holes for any manifold attachments, such as melt inlet couplings, heating components, and/or manifold locators, connectors, and alignment pins, are then machined into the manifold plates. Next, the main flow channels are drilled (e.g., gun drilled) in the manifold plates in Step 20. As previously mentioned, the diameters of the main flow channels are preferably in the range from 3 millimeters to 12 millimeters.

In Step 22, heating elements are inserted and installed into the heating element grooves that were previously milled into the manifold plates. Any number of known methods may be used to manufacture and install such heating elements, including, but not limited to, brazing, press-in, plasma spray, and the like. For more information on suitable methods for manufacturing and installing the heating elements for the present invention, see U.S. Patent No. 3,095,604, U.S. Patent No. 4,381,685, U.S. Patent No. 5,496,168, U.S. Patent No. 4,439,915, U.S. Patent No. 4,638,546, U.S. Patent No. 4,688,622, WIPO Publication No. 99/20451, European Patent No. 425,981, and European Patent No. 262,490, all of which are specifically incorporated in their entirety herein by reference.

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The injection nozzles and plugs to be used with the manifold plates are manufactured in Step 24. Any of the injection nozzles disclosed and described in the above incorporated patents may also be used with the method of the present invention. Preferably, the injection nozzles may have a standard length from 36 millimeters to 380 millimeters, a flow channel diameter from 3 millimeters to 12 millimeters, a shot weight range from 0.1 grams to 1500 grams, a variety of different nozzle tip styles, and may also be either thermal-gated or valve-gated. In one exemplary embodiment of the method of the present invention, each injection nozzle may also manufactured to be adaptive for several different gate sizes in accordance with U.S. Patent No. 4,579,520, which is specifically incorporated in its entirety herein by reference. Using an adaptive injection nozzle with the method of the present invention further standardizes the injection nozzles, and reduces manufacturing and inventory costs, since fewer nozzles can cover more sizes.

An array of different plugs, with varying diameters and lengths, may be used in the method of the present invention. For instance, the plugs may be designed to be inserted into, and oriented within, the bored holes of the manifold plates perpendicular and/or parallel to the main flow channels in the manifold plates. For more information on plugs suitable for use with the present invention, see U.S. Patent No. 5,762,976, U.S. Patent No. 6,007,108, U.S. Patent No. 5,441,197, U.S. Patent No. 5,366,369, and European Patent No. 875,355, all of which are incorporated in their entirety herein by reference. In addition to plugs, it should be understood that connector bushings may also be used with the method of the present invention. If connector bushings are manufactured and used with the present invention, however, then preferably nozzle

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manifolds are also manufactured and used together with the connector bushings for the method of the present invention. For more information on connector bushings and manifold nozzles, see U.S. Patent No. 5,792,493, which is specifically incorporated in its entirety herein by reference.

As shown in FIG. 2, the method 10 of the present invention continues with Step 26, wherein the manufactured manifold plates, nozzles, plugs, and other hot runner components (e.g., connector bushings and nozzle manifolds) are stored and placed in stock. Preferably, a selection of different manifold plates, nozzles, plugs, and other hot runner components are manufactured and stocked in order to give a customer a variety of options for manifold shapes, lengths, and thickness, nozzle types, sizes, and gate configurations, plug diameters and lengths, and combinations thereof. For purposes of the present application, Steps 12 through 26 of the method 10 will be collectively referred to herein as Phase 1. It should be understood, however, that more or fewer Steps may be included in Phase 1, and the method 10 of the present invention should not be limited to only the Steps of Phase 1 shown in FIG. 2 and described herein. In addition, it should also be understood that the particular order of the Steps in Phase 1 is not necessarily critical, and may be rearranged, depending on manufacturing preferences. Furthermore, it should be understood that Phase 1 may be performed in a continuous loop nature to keep the stocked inventory at a full level.

The method 10 of the present invention continues with Step 28, as shown in FIG. 2. In Step 28, the hot runner maker takes a customer order for a hot runner system, including the hot runner system's specifications selected from the provided ranges and options corresponding to the manifold plates, nozzles, plugs, and other hot runner components in stock. For example, a

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customer may specify a manifold plate with any standard length between 150 millimeters and 600 millimeters, any standard thickness from 25 millimeters to 40 millimeters, and any standard flow channel diameters from 3 millimeters to 12 millimeters. The customer may also specify a straight bar shape, X-shape, H-shape, Y-shape, Y-plate shape, or H-plate shape manifold plate, as well as the number of nozzles (e.g., 2 to 8) and the nozzle pitch (e.g., 30 millimeters to 250 millimeters). Finally, the customer may also specify the shapes, sizes, tip styles, gate configurations and shot weight ranges of the injection nozzles, depending on what nozzles have been manufactured and placed in stock.

In Step 30, the manifold plate, nozzles, and plugs corresponding to the customer's order and specifications are removed from stock. The method 10 proceeds with Step 32, wherein the necessary holes and slots for the plugs are bored out in the manifold plate at the locations set by the customer's order and hot runner system specifications. For example, if a customer specified a nozzle pitch range of 100 millimeters, the holes and slots for the plugs would be bored out 100 millimeters laterally from the melt inlet. As shown in FIG. 2, the holes for attaching the selected nozzles are then drilled in the manifold plate around the bored out holes and slots for the plugs in Step 34.

Next, in Step 36, the selected plugs are inserted and shrunk-fit into the bored out holes of the manifold plate, with the alignment pins of the plugs being positioned in the alignment slots. To the extent necessary, the manifold plate is then ground to its desired thickness in Step 38. For instance, if a customer specified a 30 millimeter thick manifold plate, and a 35 millimeter thick manifold plate was removed from stock in connection with the customer's order, the 35

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millimeter thick stocked manifold plate would be ground to the desired 30 millimeter thick manifold plate.

The method 10 continues with Step 40, wherein the selected injection nozzles are attached to the drilled out holes in the manifold plate surrounding the plugs. The injection nozzles are attached to the manifold plate in a manner such that the melt channel of the nozzles is aligned and in communication with the melt passage of the plugs, which in turn is aligned and in communication with the main flow channel. Any other desired finishing to complete the hot runner system is done in Step 42, and the customized hot runner system is then ready for delivery to the customer.

For purposes of the present application, Steps 28 through 40 of the method 10 will be collectively referred to herein as Phase 2. It should be understood, however, that more or fewer steps may be included in Phase 2, and the method 10 of the present invention should not be limited to only the steps of Phase 2 shown in FIG. 2 and described herein. In addition, it should also be understood that the particular order of the steps in Phase 2 is not necessarily critical, and may be rearranged, depending on manufacturing preferences.

FIGS. 3A-3J illustrate an exemplary embodiment of the method 10 of the present invention, using a straight bar shape, two nozzle hot runner system. It should be understood that hot runner systems with other shapes, configurations, and styles may be used with the method of the present invention, and the straight bar shape, two nozzle hot runner system described herein and shown in FIGS. 3A-3J was chosen for illustrative purposes only. Moreover, the sizes and

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dimensions set forth in detail below may be different for other hot runner systems, and different dimensions and sizes are contemplated for such other hot runner systems.

As shown in FIG. 3A, a straight bar shaped manifold plate 100 has a first side 102, a second side 104 opposite the first side 102, a first end 106, and a second end 108 spaced from the first end 106. The manifold plate 100 is preferably selected from a steel material (Step 12), and is manufactured with a standard length, L, and a standard thickness, T (Step 14). Preferably, the length, L, is in the range from 300 millimeters to 600 millimeters, more preferably, in the range from 322 millimeters to 572.5 millimeters, and most preferably, either 322 millimeters, 372 millimeters, 422 millimeters, 472.5 millimeters, 522.5 millimeters, or 572.5 millimeters. Similarly, the thickness, T, is preferably in the range from 25 millimeters to 40 millimeters, more preferably in the range from 30 millimeters to 37 millimeters, and most preferably 30 millimeters.

As shown in FIG. 3B, a heating element groove 110 is milled into the first side 102 of the manifold plate 100 (Step 16). A melt inlet 112, as well as holes 114 for receiving a melt inlet coupling (not shown) are drilled into the second side 104 of the manifold plate 100 (Step 18), as shown in FIG. 3C. In addition, a main flow channel 120 is drilled in the manifold plate 100 (Step 20). The main flow channel 120 preferably has a lateral portion 122 extending from the first end 106 to the second end 108 of the manifold plate 100. The main flow channel 120 preferably also has an inlet portion 124 extending between, and in communication with, the melt inlet 112 and the lateral portion 122 of the main flow channel 120. The diameter of the main

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flow channel is preferably in the range from 3 millimeters to 12 millimeters, and depends on the size of the manifold plate 100 and the type of material being used with the hot runner system.

As shown in FIGS. 3D-3F, a heating element 130 is inserted and installed into the heating element groove 110 in the first side 102 of the manifold plate 100 (Step 22). As discussed above, the heating element 130 may be fixed within the heating groove 110 via a brazing, press-fit, plasma spray, or other like method readily known in the art. The power of the heating element 130 at 220 volts is preferably in the range from 1650 watts to 2800 watts, depending on the size of the manifold and the type of material being used with the hot runner system.

The manifold plate 100 is now ready to be stocked. Although not shown, it should be understood that a number of standard nozzles and plugs have already been manufactured (Step 24) and placed in stock together with the manifold plate (Step 26). Accordingly, Phase 1 has been completed as of FIG. 3F.

Phase 2 then begins with a customer placing an order for a straight bar shaped, two nozzle hot runner system (Step 28), and the corresponding components being removed from stock (Step 30). As shown in FIGS. 3G-3H, a first bore 140 and a first alignment slot 142, as well as a second bore 144 and a second alignment slot 146, are then bored out of the manifold plate 100 (Step 32). The locations of the bores 140, 144 and the corresponding alignment slots 142, 146 depend on the nozzle pitch, X, specified by the customer's order (see Step 28). As known in the art, the nozzle pitch, X, is generally defined as the lateral distance between the center of the melt inlet and the center of a nozzle, which is typically also the center of a plug and

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its corresponding bore. The below Table 1 includes preferable nozzle pitch, X, ranges for several different manifold plate lengths, L:

X	L
100.00 – 125.00	322.0
125.01 – 150.00	372.0
150.01 – 175.00	422.0
175.01 – 200.00	472.5
200.01 – 225.00	522.5
225.01 – 250.00	572.5

Table 1

In addition to the first and second bores 140, 144 and the first and second alignment slots 142, 146, a plurality of nozzle holes 148 are also drilled in the manifold plate 100 around the first and second bores 140, 144 (Step 34). As shown in FIGS. 3I-3J, a first plug 150 having a first alignment pin 151 and a first plug channel 152 is inserted and press fit into the first bore 140 (Step 36). Likewise, a second plug 154 having a second alignment pin 155 and a second plug channel 156 is inserted and shrunk fit into the second bore 144 (Step 36). Preferably, the first and second alignment pins 151, 155 are positioned within the first and second alignment slots 142, 146, respectively. In addition, the first and second plug channels 152, 156 are aligned and in communication with the lateral portion 122 of the main flow channel 120.

Although not shown, the manifold plate may be ground to its desired thickness (Step 38), if necessary, and the nozzles may be attached with fasteners (not shown) to the manifold plate 100 via the nozzle holes 148 (Step 40). Any other finishing steps may then be performed on the customized hot runner system before it is eventually delivered to its customer (Step 42).

As previously mentioned, it should be understood that manifold plates other than the straight bar shaped, two nozzle type shown in FIG. 3J may be used with the method of the present invention. For instance, an X-shaped, four nozzle manifold plate or an H-shaped, four

nozzle manifold plate may be used with the method of the present invention. Accordingly, a detailed example of the straight bar shaped, two nozzle manifold plate is not only shown in FIG. 3K, but detailed examples of X-shaped and H-shaped, four nozzle manifold plates are shown in FIGS. 3L-3M, respectively. Tables identifying preferred nozzle pitches and manifold dimensions (e.g., manifold length, L) for each of these manifold plate types are also included in FIGS. 3K-3M.

FIG. 4 shows the proper positioning and alignment for the first plug 50 within the first bore 140 of the manifold plate 100. To avoid redundancy and unnecessary repetition, only the first plug 150 is shown in FIG. 4, since the second plug 154 is similarly situated and installed. As shown in FIG. 4, the first plug 150 is preferably positioned within the first bore 140 such that the first plug 150 is flush and even with the manifold plate 100, and the first plug channel 152 is aligned and in communication with the lateral portion 122 of the main flow channel 120. The first plug 150 is also positioned within the first bore 140 of the manifold 100 such that the first plug channel 152 is aligned and in communication with a central melt passage 165 of a nozzle 160, as shown in FIG. 4.

As shown in FIG. 5, the first plug 150 may alternatively be rotated 90° and positioned parallel to the lateral portion 122 of the main flow channel 120, rather than perpendicularly, as shown in FIG. 4. For ease of reference, this rotated first plug will be referred to herein by the reference numeral 150'. FIG. 6 illustrates the proper positioning of the first plug 150'within the manifold plate 100. In this arrangement, the first bore 140 and the first alignment slot 142 are rotated 90° to a modified first bore 140' and a first alignment slot 142'. As shown in FIG. 6, the

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first plug 150' is inserted into the manifold plate 100 parallel with the lateral portion 122 of the main flow channel 120 such that the first plug channel 152 is aligned in the communication with the lateral portion 122 of the main flow channel 120, as well as an auxiliary flow channel 170 that is aligned and in communication with a central melt channel 165 of a nozzle 160. Any auxiliary flow channel 170 is preferably drilled at the same time that the modified first bore 140' and the first alignment slot 142' are bored out of the manifold plate 100.

The method of the present invention may be applied with particular advantage to situations where a customized hot runner system needs to be quickly manufactured and assembled for a customer. By conducting most of the manufacturing and assembling for the hot runner system prior to a customer placing an order, the amount of manufacturing and assembling that needs to be done after a customer places an order for a hot runner system is minimized, thereby dramatically decreasing the amount of time required to fulfill a customer's order for a hot runner system. Moreover, by manufacturing, assembling, and stocking only standard manifold plates, injection nozzles, and plugs that can readily be customized to fit a customer's order, inventory costs can also be minimized.

It should also be readily apparent from the forgoing description and accompanying drawings that method of the present invention is an improvement over the prior art methods for manufacturing and assembling hot runner systems. For instance, the method of the present invention uses a variety of standard stock manifold plates, nozzles, and plugs for high-speed manufacturing and assembling of hot runner systems, while still providing customers with numerous options and tremendous flexibility for ordering and customizing their hot runner systems.

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In addition, unlike prior art methods, a multitude of customers can simultaneously receive fast manufacturing and assembling of their customized hot runner systems with the method of the present invention. In other words, with the method of the present invention, customer orders do not have to be put on hold or delayed to accommodate more pressing rush orders.

~~The method of the present invention is well suited for use with an online ordering system, such as an Internet-based hot runner configuration system. The assignee of the present invention operates such a system, named Merlin™, which is suitable for use with the method of the present invention. For more information on Merlin™, see the URL "www.moldmasters.com" and the commonly assigned U.S. Patent Application Serial No. __________, entitled "Method And Apparatus For An Automated Injection Molding Configuring and Manufacturing System," filed concurrently with the present application on June 6, 2000, and specifically incorporated in its entirety herein by reference.~~

Those skilled in the art to which the invention pertains may make modifications and other embodiments employing the principles of this invention without departing from its spirit or essential characteristics, particularly upon considering the foregoing teachings. Accordingly, the described embodiments are to be considered in all respects only as illustrative and not restrictive and the scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. Consequently, while the invention has been described with reference to particular embodiments, modifications of structure, sequence, materials and the like would be apparent to those skilled in the art, yet still fall within the scope of the invention.

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